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Artificial Intelligence And Expert Systems

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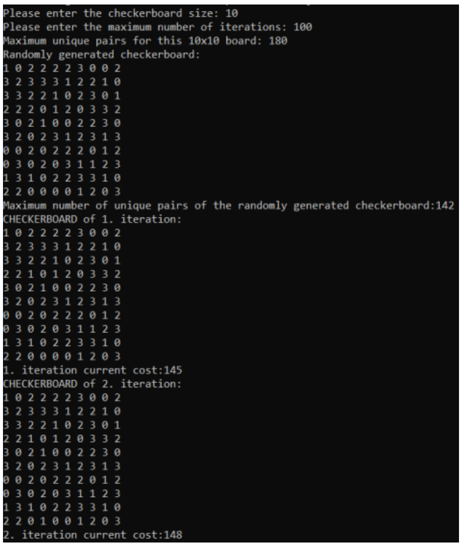
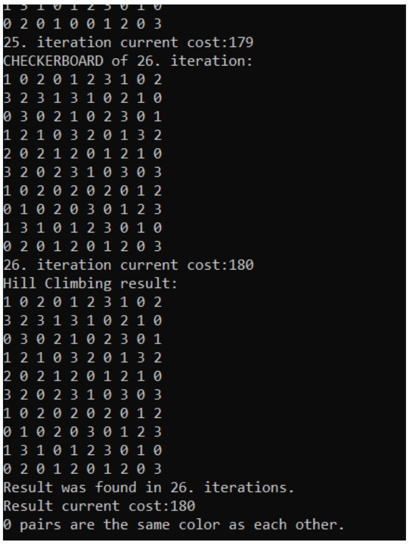
I coded both algorithms in java.

In the Hill Climbing Search, a random board is generated. All neighboring boards of this board are generated and the best one is selected. It continues in this way until the maximum unique pairs or the maximum number of iterations. If there is no better neighbor and we have not reached the maximum unique pairs, the result is returned.

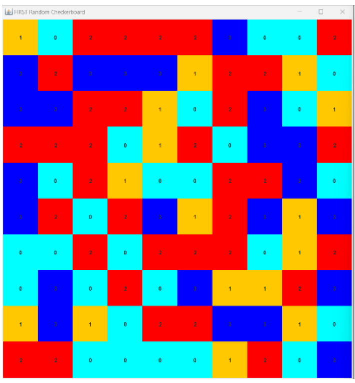
Example 1 Hill Climbing:

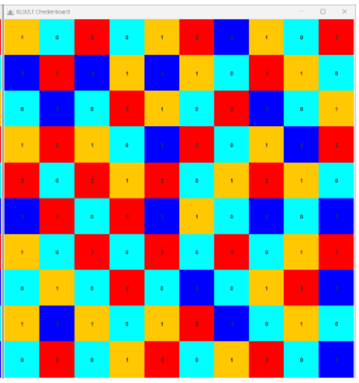


```
Please enter the checkerboard size: 10
Please enter the maximum number of iterations: 100
Maximum unique pairs for this 10x10 board: 180
Randomly generated checkerboard:
1 0 2 2 2 2 3 0 0 2
3 2 3 3 3 1 2 2 1 0
3 3 2 2 1 0 2 3 0 1
2 2 2 0 1 2 0 3 3 2
3 0 2 1 0 0 2 2 3 0
3 2 0 2 3 1 2 3 1 3
0 0 2 0 2 2 2 0 1 2
0 3 0 2 0 3 1 1 2 3
1 3 1 0 2 2 3 3 1 0
2 2 0 0 0 0 1 2 0 3
Maximum number of unique pairs of the randomly generated checkerboard:142
CHECKERBOARD of 1. iteration:
1 0 2 2 2 2 3 0 0 2
3 2 3 3 3 1 2 2 1 0
3 3 2 2 1 0 2 3 0 1
2 2 1 0 1 2 0 3 3 2
3 0 2 1 0 0 2 2 3 0
3 2 0 2 3 1 2 3 1 3
0 0 2 0 2 2 2 0 1 2
0 3 0 2 0 3 1 1 2 3
1 3 1 0 2 2 3 3 1 0
2 2 0 0 0 0 1 2 0 3
1. iteration current cost:145
CHECKERBOARD of 2. iteration:
1 0 2 2 2 2 3 0 0 2
3 2 3 3 3 1 2 2 1 0
3 3 2 2 1 0 2 3 0 1
2 2 1 0 1 2 0 3 3 2
3 0 2 1 0 0 2 2 3 0
3 2 0 2 3 1 2 3 1 3
0 0 2 0 2 2 2 0 1 2
0 3 0 2 0 3 1 1 2 3
1 3 1 0 2 2 3 3 1 0
2 2 0 1 0 0 1 2 0 3
2. iteration current cost:148
```

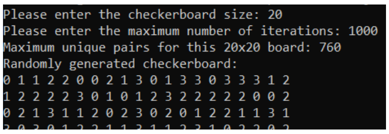


```
0 2 0 1 0 0 1 2 0 3
25. iteration current cost:179
CHECKERBOARD of 26. iteration:
1 0 2 0 1 2 3 1 0 2
3 2 3 1 3 1 0 2 1 0
0 3 0 2 1 0 2 3 0 1
1 2 1 0 3 2 0 1 3 2
2 0 2 1 2 0 1 2 1 0
3 2 0 2 3 1 0 3 0 3
1 0 2 0 2 0 2 0 1 2
0 1 0 2 0 3 0 1 2 3
1 3 1 0 1 2 3 0 1 0
0 2 0 1 2 0 1 2 0 3
26. iteration current cost:180
Hill Climbing result:
1 0 2 0 1 2 3 1 0 2
3 2 3 1 3 1 0 2 1 0
0 3 0 2 1 0 2 3 0 1
1 2 1 0 3 2 0 1 3 2
2 0 2 1 2 0 1 2 1 0
3 2 0 2 3 1 0 3 0 3
1 0 2 0 2 0 2 0 1 2
0 1 0 2 0 3 0 1 2 3
1 3 1 0 1 2 3 0 1 0
0 2 0 1 2 0 1 2 0 3
Result was found in 26. iterations.
Result current cost:180
0 pairs are the same color as each other.
```

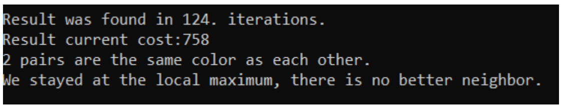




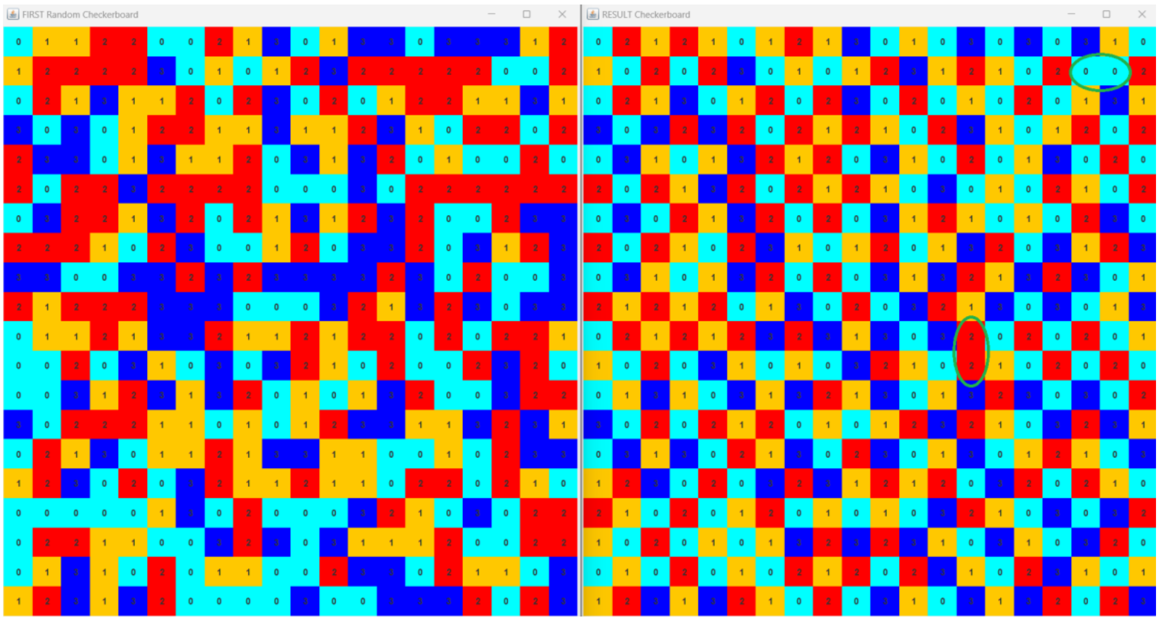
Example 2 Hill Climbing:



```
Please enter the checkerboard size: 20
Please enter the maximum number of iterations: 1000
Maximum unique pairs for this 20x20 board: 760
Randomly generated checkerboard:
0 1 1 2 2 0 0 2 1 3 0 1 3 3 0 3 3 3 1 2
1 2 2 2 2 3 0 1 0 1 2 3 2 2 2 2 2 0 0 2
0 2 1 3 1 1 2 0 2 3 0 2 0 1 2 2 1 1 3 1
```



```
Result was found in 124. iterations.
Result current cost:758
2 pairs are the same color as each other.
We stayed at the local maximum, there is no better neighbor.
```

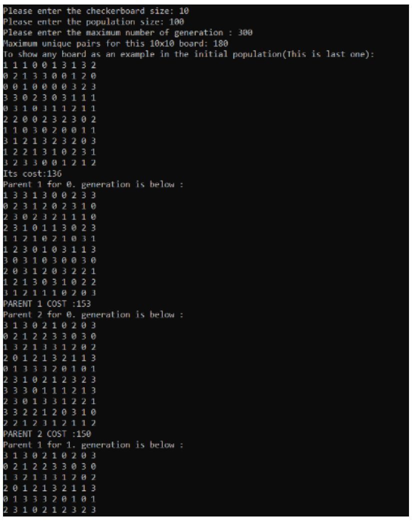


In this example, it got stuck at a local maximum and terminated because it couldn't find a better neighbor. I marked the remaining same color 2 pairs with green color.

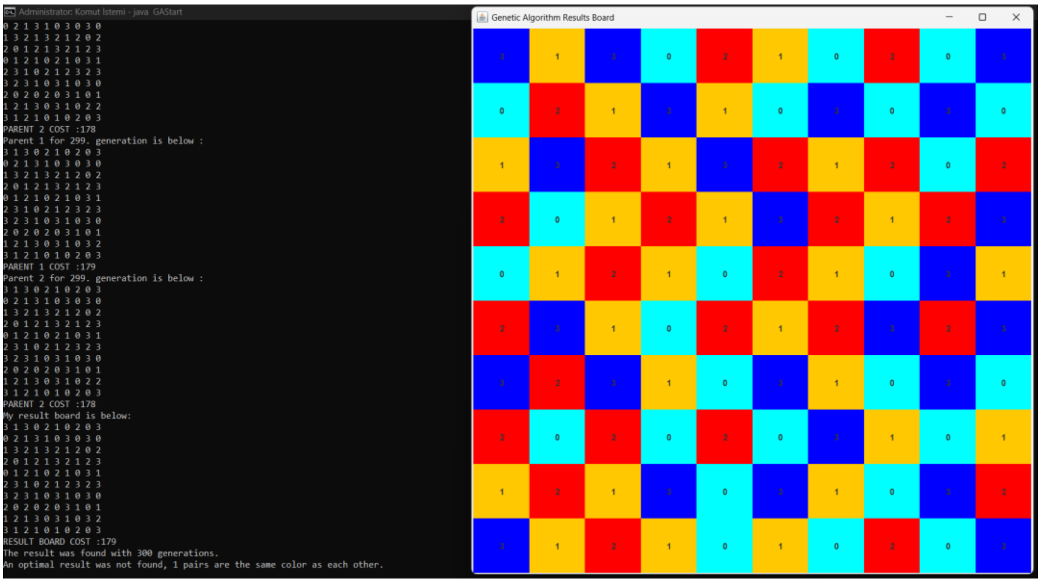
In the Genetic Algorithm, the user is asked for checkerboard size, population size and maximum number of generation. The algorithm works like this. According to the board size given by the user, population size boards are randomly created. The two best boards are selected among these boards. If it does not meet the required condition for that board size; the two best boards we choose cross over randomly horizontally and vertically and according to a randomly selected crossing over point. By default, I determined the mutation process as a 5 percent probability that one of the two children produced will mutate one color. In this way, the algorithm continues until it finds the desired condition or reaches the maximum generation number. Finally, it returns and shows the best board it found as a result.

- The mutation greatly affected the algorithm's ability to reach an optimal result. The population, which was limited before the mutation, gave a better result with the mutation.
- The genetic algorithm tends to use more memory than the hill climbing search depending on problem.

Example 1 Genetic Algorithm:

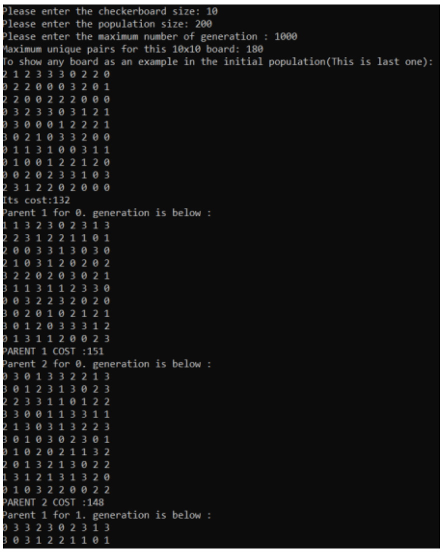


```
Please enter the checkerboard size: 10
Please enter the population size: 100
Please enter the maximum number of generation : 300
Maximum unique pairs for this 10x10 board: 180
To show any board as an example in the initial population(This is last one):
1 1 1 0 0 1 3 1 3 2
0 2 1 3 3 0 0 1 2 0
0 0 1 0 0 0 0 3 2 3
3 3 0 2 3 0 3 1 1 1
0 3 1 0 3 1 1 2 1 1
2 2 0 0 2 3 2 3 0 2
1 1 0 3 0 2 0 0 1 1
3 1 2 1 3 2 3 2 0 3
1 2 2 1 3 1 0 2 3 1
3 2 3 3 0 0 1 2 1 2
Its cost:136
Parent 1 for 0. generation is below :
1 3 3 1 3 0 0 2 3 3
0 2 3 1 2 0 2 3 1 0
2 3 0 2 3 2 1 1 1 0
2 3 1 0 1 1 3 0 2 3
1 1 2 1 0 2 1 0 3 1
1 2 3 0 1 0 3 1 1 3
3 0 3 1 0 3 0 0 3 0
2 0 3 1 2 0 3 2 2 1
1 2 1 3 0 3 1 0 2 2
3 1 2 1 1 1 0 2 0 3
PARENT 1 COST :153
Parent 2 for 0. generation is below :
3 1 3 0 2 1 0 2 0 3
0 2 1 2 2 3 3 0 3 0
1 3 2 1 3 3 1 2 0 2
2 0 1 2 1 3 2 1 1 3
0 1 3 3 3 2 0 1 0 1
2 3 1 0 2 1 2 3 2 3
3 3 3 0 1 1 1 2 1 3
2 3 0 1 3 3 1 2 2 1
3 3 2 2 1 2 0 3 1 0
2 2 1 2 3 1 2 1 1 2
PARENT 2 COST :150
Parent 1 for 1. generation is below :
3 1 3 0 2 1 0 2 0 3
0 2 1 2 2 3 3 0 3 0
1 3 2 1 3 3 1 2 0 2
2 0 1 2 1 3 2 1 1 3
0 1 3 3 3 2 0 1 0 1
2 3 1 0 2 1 2 3 2 3
```

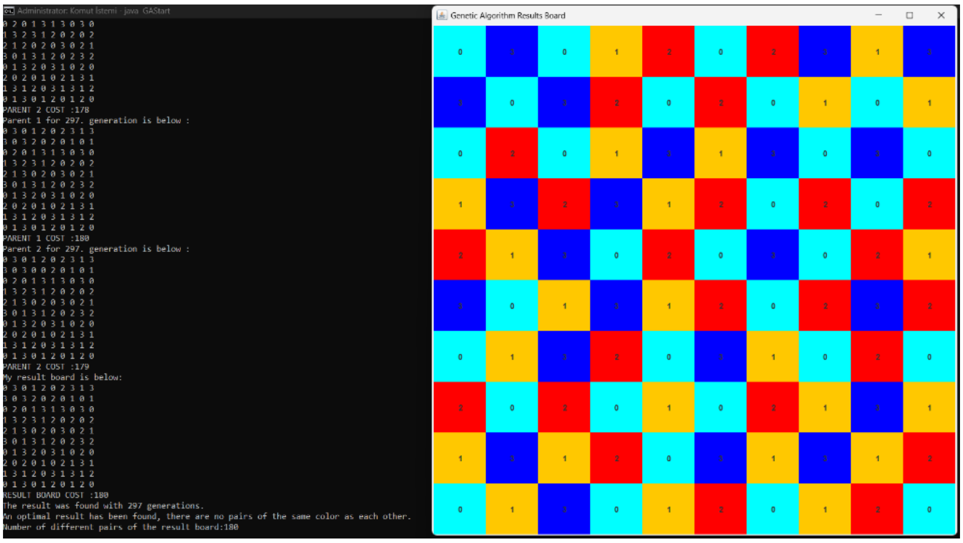

Administrator: Komut İstemi - java GAStart
Genetic Algorithm Results Board

```
0 2 1 3 1 0 3 0 3 0
1 3 2 1 3 2 1 2 0 2
2 0 1 2 1 3 2 1 2 3
0 1 2 1 0 2 1 0 3 1
2 3 1 0 2 1 2 3 2 3
3 2 3 1 0 3 1 0 3 0
2 0 2 0 2 0 3 1 0 1
1 2 1 3 0 3 1 0 2 2
3 1 2 1 0 1 0 2 0 3
PARENT 2 COST :178
Parent 1 for 299. generation is below :
3 1 3 0 2 1 0 2 0 3
0 2 1 3 1 0 3 0 3 0
1 3 2 1 3 2 1 2 0 2
2 0 1 2 1 3 2 1 2 3
0 1 2 1 0 2 1 0 3 1
2 3 1 0 2 1 2 3 2 3
3 2 3 1 0 3 1 0 3 0
2 0 2 0 2 0 3 1 0 1
1 2 1 3 0 3 1 0 3 2
3 1 2 1 0 1 0 2 0 3
PARENT 1 COST :179
Parent 2 for 299. generation is below :
3 1 3 0 2 1 0 2 0 3
0 2 1 3 1 0 3 0 3 0
1 3 2 1 3 2 1 2 0 2
2 0 1 2 1 3 2 1 2 3
0 1 2 1 0 2 1 0 3 1
2 3 1 0 2 1 2 3 2 3
3 2 3 1 0 3 1 0 3 0
2 0 2 0 2 0 3 1 0 1
1 2 1 3 0 3 1 0 2 2
3 1 2 1 0 1 0 2 0 3
PARENT 2 COST :178
My result board is below:
3 1 3 0 2 1 0 2 0 3
0 2 1 3 1 0 3 0 3 0
1 3 2 1 3 2 1 2 0 2
2 0 1 2 1 3 2 1 2 3
0 1 2 1 0 2 1 0 3 1
2 3 1 0 2 1 2 3 2 3
3 2 3 1 0 3 1 0 3 0
2 0 2 0 2 0 3 1 0 1
1 2 1 3 0 3 1 0 3 2
3 1 2 1 0 1 0 2 0 3
RESULT BOARD COST :179
The result was found with 300 generations.
An optimal result was not found, 1 pairs are the same color as each other.
```

Example 2 Genetic Algorithm:



```
Please enter the checkerboard size: 10
Please enter the population size: 200
Please enter the maximum number of generation : 1000
Maximum unique pairs for this 10x10 board: 180
To show any board as an example in the initial population(This is last one):
2 1 2 3 3 3 0 2 2 0
0 2 2 0 0 0 3 2 0 1
2 2 0 0 2 2 2 0 0 0
0 3 2 3 3 0 3 1 2 1
0 3 0 0 0 1 2 2 2 1
3 0 2 1 0 3 3 2 0 0
0 1 1 3 1 0 0 3 1 1
0 1 0 0 1 2 2 1 2 0
0 0 2 0 2 3 3 1 0 3
2 3 1 2 2 0 2 0 0 0
Its cost:132
Parent 1 for 0. generation is below :
1 1 3 2 3 0 2 3 1 3
2 2 3 1 2 2 1 1 0 1
2 0 0 3 3 1 3 0 3 0
2 1 0 3 1 2 0 2 0 2
3 2 2 0 2 0 3 0 2 1
3 1 1 3 1 1 2 3 3 0
0 0 3 2 2 3 2 0 2 0
3 0 2 0 1 0 2 1 2 1
3 0 1 2 0 3 3 3 1 2
0 1 3 1 1 2 0 0 2 3
PARENT 1 COST :151
Parent 2 for 0. generation is below :
0 3 0 1 3 3 2 2 1 3
3 0 1 2 3 1 3 0 2 3
2 2 3 3 1 1 0 1 2 2
3 3 0 0 1 1 3 3 1 1
2 1 3 0 3 1 3 2 2 3
3 0 1 0 3 0 2 3 0 1
0 1 0 2 0 2 1 1 3 2
2 0 1 3 2 1 3 0 2 2
1 3 1 2 1 3 1 3 2 0
0 1 0 3 2 2 0 0 2 2
PARENT 2 COST :148
Parent 1 for 1. generation is below :
0 3 3 2 3 0 2 3 1 3
3 0 3 1 2 2 1 1 0 1
```


Administrator: Komut İstemi - java GAStart
Genetic Algorithm Results Board

```
0 2 0 1 3 1 3 0 3 0
1 3 2 3 1 2 0 2 0 2
2 1 2 0 2 0 3 0 2 1
3 0 1 3 1 2 0 2 3 2
0 1 3 2 0 3 1 0 2 0
2 0 2 0 1 0 2 1 3 1
1 3 1 2 0 3 1 3 1 2
0 1 3 0 1 2 0 1 2 0
PARENT 2 COST :178
Parent 1 for 297. generation is below :
0 3 0 1 2 0 2 3 1 3
3 0 3 2 0 2 0 1 0 1
0 2 0 1 3 1 3 0 3 0
1 3 2 3 1 2 0 2 0 2
2 1 3 0 2 0 3 0 2 1
3 0 1 3 1 2 0 2 3 2
0 1 3 2 0 3 1 0 2 0
2 0 2 0 1 0 2 1 3 1
1 3 1 2 0 3 1 3 1 2
0 1 3 0 1 2 0 1 2 0
PARENT 1 COST :180
Parent 2 for 297. generation is below :
0 3 0 1 2 0 2 3 1 3
3 0 3 0 0 2 0 1 0 1
0 2 0 1 3 1 3 0 3 0
1 3 2 3 1 2 0 2 0 2
2 1 3 0 2 0 3 0 2 1
3 0 1 3 1 2 0 2 3 2
0 1 3 2 0 3 1 0 2 0
2 0 2 0 1 0 2 1 3 1
1 3 1 2 0 3 1 3 1 2
0 1 3 0 1 2 0 1 2 0
PARENT 2 COST :179
My result board is below:
0 3 0 1 2 0 2 3 1 3
3 0 3 2 0 2 0 1 0 1
0 2 0 1 3 1 3 0 3 0
1 3 2 3 1 2 0 2 0 2
2 1 3 0 2 0 3 0 2 1
3 0 1 3 1 2 0 2 3 2
0 1 3 2 0 3 1 0 2 0
2 0 2 0 1 0 2 1 3 1
1 3 1 2 0 3 1 3 1 2
0 1 3 0 1 2 0 1 2 0
RESULT BOARD COST :180
The result was found with 297 generations.
An optimal result has been found, there are no pairs of the same color as each other.
Number of different pairs of the result board:180
```